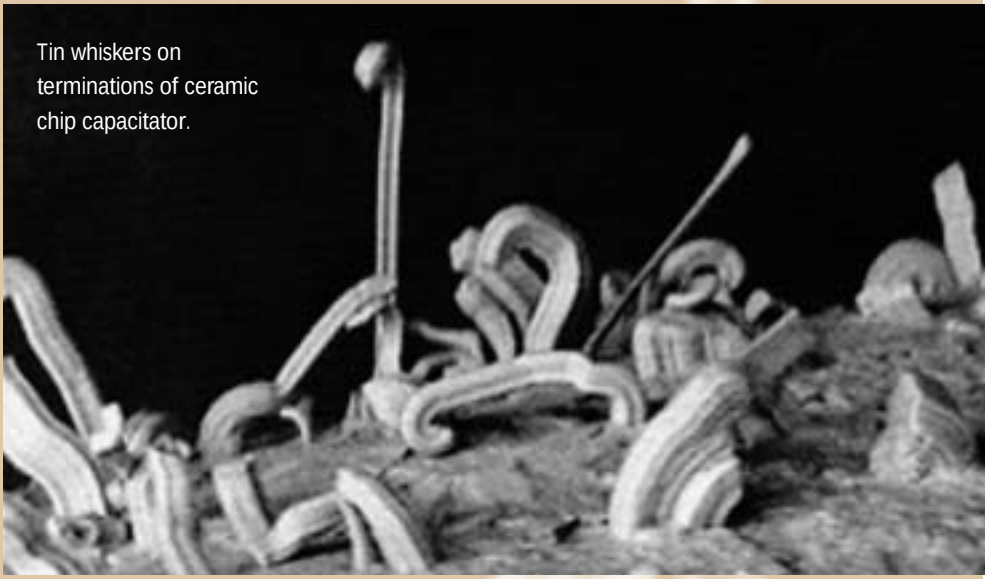
Tin Whiskers Threaten Reliability of Electronics Components

DAU Strategic Partner BMPCOE Leads Mitigation Research

The Office of Naval Research's Best Manufacturing Practices Center of Excellence (BMPCOE) is a partnership among the BMP Program, the Department of Commerce, and the University of Maryland, College Park. DAU is a strategic partner and a BMPCOE Satellite Center. Since its creation in 1985, BMP has set out to help businesses identify, research, and promote exceptional manufacturing practices, methods, and procedures.

BMPCOE's objective is to empower defense and commercial customers to operate at a higher level of efficiency and effectiveness. To this end, BMPCOE has three core competencies represented by tools and resources that enable organizations to identify and apply best practices and to become part of a vast, mutually supportive information exchange network:

- **On-site Surveys**—conducted with the goal of identifying best practices, validating and documenting them, and then encouraging government, industry, and academia to share information and implement the practices where applicable.
- **Systems Engineering**—facilitated through BMPCOE's Program Manager's WorkStation (PMWS), a suite of electronic tools that provide risk management, engineering support, and failure analysis through integrated problem solving.
- **Web Technologies**—offered through the Collaborative Work Environment (CWE) to provide users with an integrated digital environment to access and process a common set of documents regardless of user location or platform.



Tin whiskers on terminations of ceramic chip capacitator.

Tin whiskers are single crystal, electrically conductive, hair-like structures that grow from lead-free pure tin surfaces.

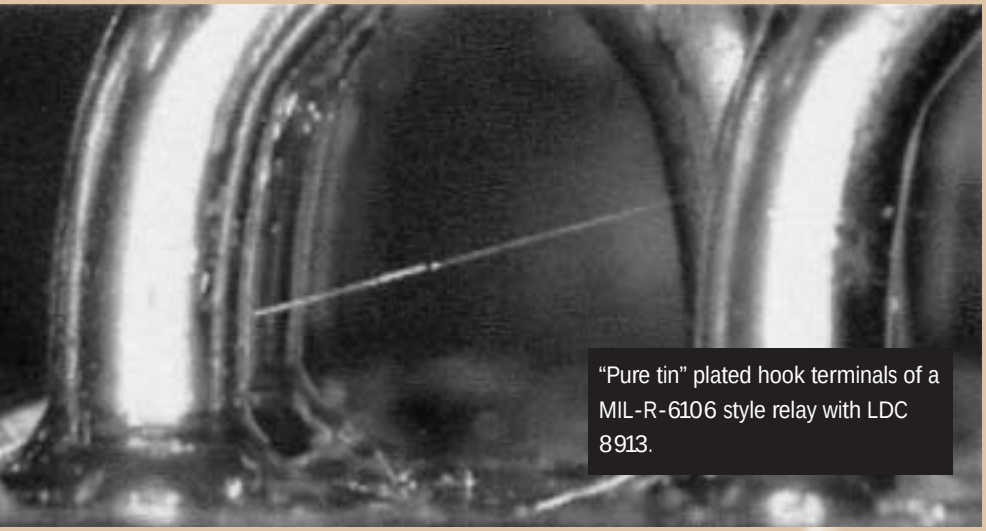
Tin Whiskers: A Growing Risk

BMPCOE has demonstrated excellence not only through the performance of its core competencies, but also by its ongoing efforts in solving emerging problems and researching manufacturing techniques. One of BMPCOE's primary contributions to the Fleet's operational effectiveness is its long-standing support to the STANDARD Missile (SM) programs. BMPCOE staff are now part of the vanguard of the Navy team actively pursuing the mitigation of a phenomenon known as "tin whiskers."

Tin whiskers are single crystal, electrically conductive, hair-like structures that grow from pure tin surfaces. Whiskering can develop under typical operating conditions on any product type (not just electronics) that uses lead-free pure tin coatings, and it has been found to form in a wide range of applications, including space, missile, airborne, and medical. This emerging problem presents serious safety, reliability, and potential liability threats for a wide variety of electronic systems employing components plated with tin, including military and aerospace programs requiring high-reliability electronic components and assemblies.

The tin whisker failure mode, electrical shorting, has been responsible for the loss of billions of dollars' worth of satellites, missiles, and other equipment. At

Photos courtesy NASA Goddard Space Flight Center



"Pure tin" plated hook terminals of a MIL-R-6106 style relay with LDC 8913.

least three commercial satellites have failed as a result of blown fuses and relays attributed to tin whiskers. Although observed for decades, the causes of tin whiskering are still not fully understood.

Current Mitigation Practices

For many years, tin-lead alloy coatings have been used in lieu of pure tin coatings as a standard procedure to suppress whisker growth. In recent years, environmental concerns and the associated market pressures have fueled a movement to transition to lead-free electronics. (The European conversion to lead-free components is scheduled to take effect in June 2006.) We are at a transitional point where numerous changes are affecting the standard materials and finishes offered by component manufacturers. Many major suppliers are already offering only lead-free finishes, usually pure tin. Even though some have expressed an intent to maintain a dual product line (tin-lead and lead-free), the expectation is that in time, they too will be forced by financial pressures into solely lead-free production.

An alternative to tin-lead in mitigating some types of tin whisker-related failures is conformal coating, a process whereby components are sprayed with a substance (such as silicone, parylene, urethane, acrylic, or epoxy) to retard the growth of whiskers or to contain them within the coating. However, conformal coating can be expensive and must maintain the exact thickness for prevention if it is not to cause additional problems. Although plating and soldering chemists and metallurgists are pursuing new technologies to limit tin whiskering, the success of these efforts is uncertain and may not be available for many years.

Designers, engineers, and program managers are faced with a complex and dynamic risk situation. There are currently no dependable tests to predict whisker formation and no proven methods to prevent its occurrence. And with the move to lead-free components, the use of pure tin plating as a standard finish on electronics components is on the increase and will continue to increase in the future.

BMPCOE-Raytheon Project

BMPCOE experts were successful in identifying the tin whiskers risk to the SM programs and in raising the awareness of both Navy and contractor managers. BMPCOE, with the SM prime contractor Raytheon, is now co-managing a project to conduct research and to develop a two-part strategic action plan addressing the tin whiskers problem. A large government/industry/academia project team includes participants from the University of Maryland CALCE Electronic Products & Systems Center; NASA; Boeing; Honeywell; Northrop Grumman; the Naval Air Warfare Center, China Lake; and others.

The team of experts must first define stop-gap procedures that will be used across sites or programs in the short term. Second, the project team must investigate mitigation alternatives to be performed in the medium term. The results will be used to update the short-term solutions and will eventually become the properly substantiated industry best practices. This work should help all high-reliability users to mitigate the risk associated with tin-coated components. The availability of a standard process for dealing with tin would serve to enhance the reliability and cost-effectiveness of products that would otherwise have been developed and built without addressing tin whisker control. This will continue to improve Fleet reliability and customer satisfaction, and to provide cost avoidance for both contractors and customers.

BMPCOE Seeks Additional Support

As BMPCOE experts work with the many participating organizations in multiple locations to devise policies for handling tin usage, efficient coordination and data sharing will eliminate duplication of effort and result in faster solutions. BMPCOE is presently looking for support from other Navy program offices and military services and for in-kind support from Department of Defense contractors to expand the current consortium for greater productivity.

While BMPCOE is involved in many projects, tin whiskers mitigation is a priority because of the high and immediate risk factor. BMPCOE continues to support SM programs in risk management and systems engineering; to work diligently in resolving the risks associated with tin coatings; and to strive for excellence through increasing the quality, reliability, and maintainability of U.S. defense and commercial manufacturers.

Editor's Note: The Navy's BMPCOE and DAU partnership continues to bring the acquisition workforce the latest in technical tools and information. For further information, contact Bill Motley at bill.motley@dau.mil, call BMPCOE at (301) 403-8100, or visit the BMPCOE Web site at http://www.bmpcoe.org.